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Decreasing suitable land for Maize production in Nigeria; assessments with the synchrony of conventional and geospatial techniques

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ABSTRACT

Rapidly increasing global population has triggered ever-increasing demand for arable crops such as maize. This has necessitated the need for increase in the precision of soil characterization for maize production in Nigeria - the most populous country in Africa. This study used the Integration of geospatial methods with conventional land assessment methods to overcome the limitations of conventional soil mapping. The study aims at integrating parametric methods with geospatial techniques in land suitability assessment for maize production. Three pedons at three predominant physiographic positions viz: upper, middle and valley bottom in the study locations around Ibadan, Southwest Nigeria were characterized and described following the Food and Agricultural Organization (FAO) soil characterization guideline. Suitability assessment for maize production was conducted using Storie's

parametric, inverse distance weighted techniques and remote sensing. Land use and land cover were characterized with remote sensing at year 2000 and 2015 respectively. Suitability for maize was classified into three suitability categories namely, Moderately (S3), Marginally (S2) and Not suitable (NS). The results show 70 % of green vegetation and arable land loss to urbanization from 2000-2015. These changes led to reduction in suitable land for maize cultivation.

Keywords: Land suitability, parametric methods, geospatial mapping, maize, Alfisols, Entisols, land use

1. INTRODUCTION

There were nearly 925 million hungry people in the world and the number has increased drastically (FAO 2010). Maize (*Zea mays*) is an annual grass in the *Poaceae* (grass family) that originated in Central America and is one of the top three cereal crops grown in the World, along with rice (*Oryza sativa*) and wheat (*Triticum* spp.). Maize is one of the five food crops promoted in the attainment of food self-sufficiency in Nigeria (FAO, 2009; Sayyadi, 2008).

Land suitability assessment is the investigation of land's appropriateness for a specific type of land use (Abdelrahman et al., 2016). This assessment involves many factors that directly or indirectly control the ability of land to support the purpose under investigation. Land suitability has traditionally been based primarily on soil survey while soil characterization and classification will serve as efficient tools in land suitability assessment. Mapping of soils using conventional soil survey tends to be limited when fast, accurate and up-to-date information about soil is required. Furthermore, conventional soil mapping serves as a means of understanding information about soil but the information are not easily accessible, accurate and easy to update especially when the result are display in maps. Hence, geospatial techniques could eliminate this limitation in conventional soil mapping and further helps to integrate both conventional and digital soil mapping for a better decision making. However, the use of digital soil mapping which is said to be a better alternative to conventional soil mapping need to be explored in order to complement the changes in land use and to make more informed decisions on land use planning and implementation (Baja et al., 2007).

The benefits that accrue from using GIS to evaluate soil suitability have led to increase in food security and sustainable livelihoods (United Nations 2012). Previous studies have shown that integration of geospatial techniques such as remote sensing has led to efficient and effective mapping of agricultural lands. Vargahan et al., (2011) compare four land suitability methods (Simple limitation, limitation regarding number and intensity, Storie and Square root) and revealed that, square root parametric method is mainly better and more commonly used method in quantitative evaluation. Abdelrahman et al., (2016) reported that conventional land evaluation methods suffer from limitation of spatial analysis for the suitability of various crops. However, most of these studies made comparison between conventional and geospatial techniques without evaluating measures of synchronizing the two techniques. Integrating G.I.S with soil survey could give a faster and more efficient way of grouping soils into suitability classes for specific agricultural land use types especially when the soil has been characterized. Therefore, this study aims at assessing land suitability for maize by synchronizing conventional and geospatial techniques.

Objectives

To evaluate the soil physical and chemical properties.

To assess the land use and land cover using geospatial techniques.

To create a synchrony between parametric and geospatial techniques for maize production.

2. METHODOLOGY

The study area

The city of Ibadan is the largest city in West Africa and its located in South-Western Nigeria (Fig 1). Ibadan lies essentially in a zone of transition between the humid and sub humid tropical climates within latitudes 7° 16' North and 7° 34' North, Longitudes 3°44' East and 4° 02' East approximately 145 kilometer North of Lagos. The 2006 census put the total population of Ibadan to 2,550,593 while the average population density was 828 persons per km^2 (NPC, 2006). The geology of Ibadan is described as a basement complex of Precambrian age with mainly granite, quartzite, and migmatite as the dominant rock types. The Lade parts of Ibadan (Fig 1) which was chosen for this study was an agrarian community but has gained tremendously from industrialization process with the presence of industries such as Nigerian wire and cable limited, Nigerian mining Cooperation and Nigerian National Petroleum Company among others.

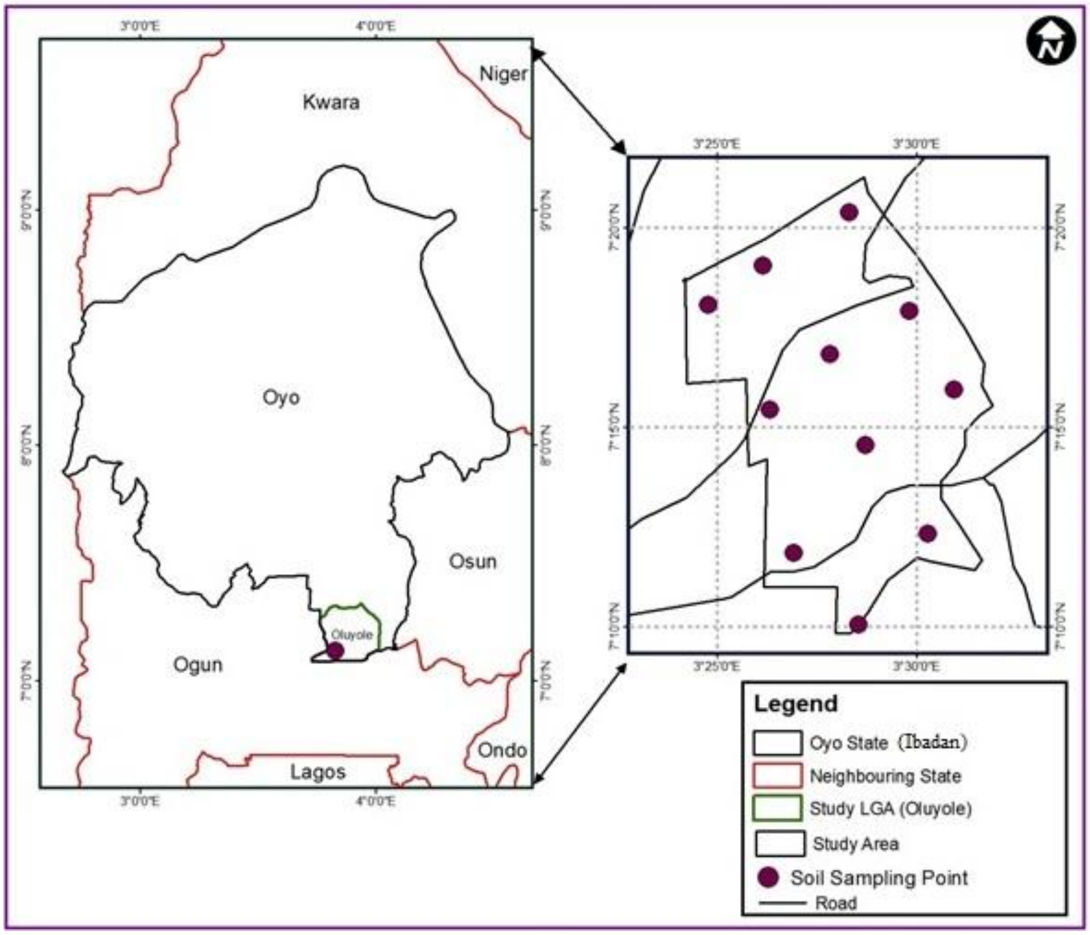

Figure 1 Map of the study Area

Data and geospatial techniques

The data were processed on ArcGIS 10.2 and ENVI 4.2. These include Shuttle Radar Topographic Mapper (SRTM) of Digital Elevation Model having 90 meter resolution (Reuter et al., 2007) and LANDSAT satellite imageries. Topographic maps (1:50,000) were generated for digital elevation model (DEM) while the LANDSAT imagery was used for Land use / cover change analysis. In line the previous studies, the (Satellite imagery) band combinations used for this study were (RGB) 4, 3, and 2 (Kiage et al., 2007). Four categories of land use and land cover information were derived from the remotely sensed data namely: bare ground/farmland, vegetation, water body/wetland, and built up. Thematic maps such as base map and soil map were also used. The ground control points were super-imposed using grid cell based overlay-modeling technique (Kiage et al., 2007). Thereafter, digital terrain and contour map was generated from the SRTM90-meter resolution which guide in soil unit identification. The land use and land cover of year 2000 and 2015 of the study area were assessed in ENVI 4.8 remote sensing software using Land Sat Enhanced thematic mapper. Supervised classification algorithm of maximum classification algorithm and region of interest were used to identify land use and land cover features of the study and these are bare ground/farmland, vegetation, water body/wetland, and built up.

Spatial analysis

Each soil characteristic with associated attribute data was digitally encoded in a geographic information system (GIS) database to eventually generate seven thematic layers. The soil data were tied with their coordinate and then inserted into excel sheet in order to assess it in ArcGIS 10.2 software. Soil properties were interpolated using Inverse distance weighted interpolation techniques described in Setianto and Triandini, (2013). IDW interpolation explicitly implements the assumption that things that are close to one another are more alike than those that were farther apart. To predict a value for any unmeasured location, IDW were used to measure neighborhood values in the predicted location. Assumes value of an attribute Z at any un-sampled point was a distance-weighted average of sampled points lying within a defined neighborhood around that un sampled point (Richards, J.A., 1999, Setianto and Triandini, 2013). The soil properties were attached to the coordinate point and this were inserted in an excel sheet and

further plotted into ArcMap 10.2 software. Thereafter, the soil properties were subjected to spatial analysis. The interpolated map were further overlaid digitally and analyzed for maize suitability using methods of Dent and Young suitability model in line with Mohammd et al., (2010).

Conventional Soil Mapping

The area was sampled using rigid grid survey to cover the entire representative area selected for the study. A reconnaissance survey was carried out in order to have a general knowledge about the study area. After the reconnaissance, base map was produced with the aid of global positioning system and topographic map of the study area. Soil samples were collected with the aid of soil auger at predominant land types (viz: Upper, middle and valley bottom). At each of the selected site, soil sample were collected at 0-15cm for soil fertility assessment since maize is a shallow rooted crop. Co-ordinates of the individual soil sampling points were documented. Representative soil profile pits measuring 2 m x 1.5 m x 2 m were dug, each at predominant land types represented by the physiographic positions or slope segments of the topo sequence encountered on the site. A total of 3 profile pits were dug and were described morphologically in line with the FAO, (2009) procedure Soil samples were collected from the different pedogenic horizons and then processed in the laboratory after air-drying at room temperature.

Laboratory Analysis

The following soil parameters were determined: nitrogen, potassium, phosphorus, hydrogen ions, soil texture, soil structure, hydraulic conductivity, bulk density and soil pH. The particle size was determined by hydrometer method Bouyoucous described in Beretta et al., (2014). Total nitrogen was determined calorimetrically. Available phosphorus was extracted by Bray 1 method (Anderson and Ingram, 1993; Flavio et al., 2011) and phosphorus concentration was determined using a ultra violet spectrophotometer. Soil organic carbon was determined by dichromate oxidation procedure and organic matter was determined by carbon factor. Exchangeable bases (Calcium, Magnesium, Potassium, and Sodium) were extracted with neutral ammonium acetate. Ca and Mg were determined with Atomic Absorption spectrometry while K and Na were determined by flame photometer. Base saturation and effective cation exchange capacity were calculated. Soil pH was determined in a 1:2 soil to water suspension using a glass electrode pH meter. Bulk density (BD) was determined from undisturbed core samples was after being oven dried to constant weight at $105^{O}C$.

Soil classification

Based on morphological characteristics and laboratory data, the soils were classified into Series level using the method developed by Smyth and Montgomery (Fasina et al., 2015) for soils on basement parent rock materials in South western Nigeria. At higher categories, the soils were classified using the USDA Soil Taxonomy (Soil Survey Staff, 2010) and the World Reference Base (WRB) system of FAO/IUSS Working Group (2010).

Land suitability evaluation approach

Land suitability classification in this study was based on the FAO framework of land evaluation guidelines as used by Chinene (2007). The FAO's land suitability scheme is divided into Order, Class, Sub Class, and Unit. Order is the global land suitability group, and is divided into S (Suitable) and N (Not Suitable). Class is the land suitability group within the Order level. Nurmiaty et al., (2013) stated that the accuracy ofland suitability classification is based on the level of detail of the data available. In this study, suitability classification was done at the class and sub-class levels according to the FAO framework for land evaluation Table 1. The classification at class level adopted is as follows:

1. Class S1 (highly suitable): land having no significant limitation or only have minor limitations to sustain a given land utilization type without significant reduction in productivity or benefits and will not require major inputs.
2. Class S2 (moderately suitable): land having limitations which in aggregate are moderately severe for sustained application of the given land utilization type. The limitations will reduce productivity or benefits and increase required inputs to the extent that the overall advantage to be gained from the use, although still attractive, will be appreciable compared to that expected from Class S1 land.
3. Class S3 (marginally suitable): land having limitations which in aggregate are severe for sustained application of the given land utilization type and will so reduce productivity or benefits, or increase required inputs, that any expenditure will only be marginally justified: Class N (not suitable): land having very severe limitations, as the range of inputs required is unjustifiable.

Table 1 Suitability Index table

Suitability Class	Suitability Index
Class S1: Highly Suitable	> 75
Class S2 : Moderately Suitable	50 – 75
Class S3: Marginally Suitable	25 – 50
Class N1: Marginally Not Suitable	10 – 25
Class N2: Permanently Unsuitable	< 10

Parametric rating techniques and land indices

The numbers of land qualities/ characteristics considered were limited to those that have been identified as important to the growth and yield of maize. This was done to avoid repetition of characteristics which may depress the final land index. Therefore, all the land qualities expressed by one characteristic were rated together. As such; a single rating of the soil texture has been done with regards to the capacity to retain nutrients, water availability, permeability and drainage. An important characteristic was rated in a wide scale of 100-20, while a less important one was rated in a narrower scale of 100-60. This has introduced the concept of weighting factor into the rating. The rating of 100 was applied for optimal development or value of a characteristic. However, if some characteristics were better than the usual optimal, the maximum rating was chosen higher than 100. The depth to which the land index was calculated and defined for each land utilization type. Land indices were calculated before converting them to suitability classes using the equation below (Storie, 1978; Baroudy, 2016):

$$S_i = A\ x\ B/100\ x\ C/100\ \ldots\ldots..n/100 \qquad \text{EQ1}$$

Where;

S_i = Index of suitability

A = Index of the most limiting characteristic

B = Index of topography

C = Index of moisture availability

n = Index of nth characteristic

The index of suitability (S_i) was then converted to suitability class using Sys conversion (Table 2) (Baroudy, 2016).

Table 2 Land requirement and suitability classes for maize production

Land characteristics	SI1	SI2	S2	S3	N1	N2
	100	95	85	60	40	25
Topography (t)						
Slope (%)	0-2	2-4	4-8	8-16	16-20	>20
Slope (%)	0-4	4-8	8-16	>16	-	-
Moisture availability (c)						
Total rainfall during the growing season (mm)	800-1200	700-800	600-700	500-600	<500	-
Oxygen availability (w)						
Drainage	Good	Moderate	imperfect/rapid	poor/very excess	poor but drainable	poor but not drainable

Nutrient availability (0-20cm) (f)						
Total N (%)	>0.15	0.08-0.15	0.08-0.04	0.02-0.04	<0.02	any less
Avail P (mg/kg)	>22	13-22	6-13	3-6	<3	any less
Potassium (Cmol/kg -1)	>0.5	0.3-0.5	0.2-0.3	0.1-0.2	<0.1	Any
CEC	>15	10-15	5-10	3-5	<3	-
Base saturation						
(%)	>80	30-50	35-50	20-50	<20	-
(%)	>70	50-70	35-70	<35	-	-
Organic matter						
(g/kg)	>3	1-3	0.8-1	0.4-0.8	<0.4	-
Physical soil characteristics						
Texture/structure Gravel	CL	SC, SCL, L	SL, LS	LS, fS	Cm, S, cS	-
(%)	<15	15-40	40-60	60-75	75-90	>90
(%)	<40	40-75	75-80	80-90	>90	-
(%)	<20	20-40	40-75	>75	-	-
Soil depth (cm)	>90	50-90	30-50	20-30	10-20	<10
Bulk density (g/cm^3)	<1.0	1.0-1.21	1.22-1.51	1.51-1.63	1.63-2	>2

Source: Oluwatosin and Ogunkunle (1991)

Texture: cl: =clay loam, scl: =sandy clay loam, ls=loamy sand, sc=sandy clay, SII: Highly Suitable, S12: Highly Suitable, S2: Moderately Suitable, S3: Marginally Suitable, N1: Not Suitable, N2: Permanently

The following land qualities/characteristics were used: climate: annual rainfall, mean temperature (c), Soil physical characteristics: soil depth, texture, clay content (s), Wetness, drainage (w), Topography: slope percent (t), nutrient availability (f): pH, N, P, K, Mn, Fe, Cu, Zn, Nutrient retention capacity (n): Organic matter, Base status and Effective cation exchange capacity (ECEC). The land characteristics (LC) for each soil series was matched with the land use requirements for maize. Land requirement and suitability classes for maize production are shown in Table 3. Suitability classes were derived from the matching using Storie parametric approach (Baroudy, 2016).

3. RESULTS AND DISCUSSION

Physical and chemical soil properties

The studied soils varied from sandy loam to sandy clay loam in texture while the soil colour varied from very dark greenish brown (10YR 3/2), dark reddish brown (7.5 YR 4/2) to yellowish red (5YR 5/8) with an inclusion of yellowish brown (10 YR 5/8). There were no serious changes in the profile soil colour except that of the lower slope. The soil texture and depth were rated into highly suitable covering 90% and 80%, bulk density was rated into moderately suitable covering 60%. The soil pH was acidic and it ranges between 5.69 to 6.21 at the surface and sub-surface and this shows the release or discharge of industrial waste or effluent which could be the upward movement of bases of intense evapotranspiration and this is also supported by work done by Amusan (1991). Total nitrogen ranged from medium to very high (0.03 – 3.1%) at the surface and sub-surface, available phosphorus concentration ranged from low to medium (1.32 – 8.89 mg/kg) at the surface and that of the sub-surface, potassium was found to be very low and low (0.01 to 0.3 cmol/kg), copper (Cu) ranged from high to very high (1.33 to 6.48 mg/kg) at the surface and at the sub-surface, iron (Fe) ranged from High to very high (130.60 – 233.85 ppm). The high concentration of iron (Fe) content is as a result of deposition of industrial effluent or discharge to the river which flow across the study area. Zinc (Zn) ranged from low to high (1.26 to 5.05 mg/kg) at the surface and sub-surface. The result of the micro-nutrients in the study area shows that the distribution of these elements was irregular down the soil profile. Soil organic matter (SOM) content ranged low to high (1.22 – 4.21%) from surface and sub-surface.

Land use/land cover (LU/LC) classification

The main aim of land use and land cover mapping in this study is to provide thematic information on different land use and land cover categories as a basis for assessing the soil fertility. From Table 3, in year 2000,

vegetation is mostly dominated covering 162.2 sqkm (55%) followed by built up 110.49 sq km (38%), bare ground 10.46 sq km (4%), and water body 8.65 sq km (3%) while in year 2015, built up were found to be 181.9 sqkm (62%) followed by vegetation 60.01 sq km (21%), water body 29.58 sq km (10%) and bare ground covering 20.46 sq km (7%). The evidence of the high density of the built-up areas in year 2015 could be attributed to the encroachment of farm land or conversion of farmland into commercial, industrial and residential building and Fabiyi (1999) stated that the dynamics growth also reflects the absence of state control of the use of land and building activities which has led to the failure of land use policy. The land use and land cover area covered are shown in table 4.

Table 3 Land use and land cover Area

LU/LC	2000		2015	
	Area (Sqkm)	%	Area (Sqkm)	%
Vegetation	162.02	55	60.01	21
Built up	110.49	38	181.09	62
Waterbody	8.65	3	29.58	10
Bareground	10.46	4	20.46	7
Total	292	100	292	100

Table 4 morphological classification of the study soils

Horizon Designation	Depth (cm)	Soil Colour	Munsell Colour	Texture	Structure	Consistence	Root Conc.	Boundary
Ap	0 – 5	Db	10 YR2/1	SL	Msab	h,vf,ns,np	af	cs
B1	5 - 15	Db	7.5YR 5/4	SL	Msab	h,vh,vf,ss,p	mf	cs
B2	15 -29	Drb	2.5 YR 3/4	SC	Msab	vh,vf,ss,p	mf	wb
B3	29 - 60	Sb	7.5 YR 5/6	SC	Msab	vh,f,vs,p	ND	ND
Bt	60 - 110	Yr,g	5 YR 5/8, 10YR 5/1	SC	Wsab	vh,f,np,ss	ND	ND
Ap	0 - 11	dgb, vdgb	10 YR 4/2, 10 YR 3/2	SL	Msab	l,f,np,ns	mcf	wb
A1	11 - 33	yb, dyb	10 YR5/4, 10 YR 3/2	SC	Wsab	l, f,sp,ss	mcf	cs
B1	33 - 40	Yb	10 YR 5/8	SC	Wsab	sh,f,ss,sp	ccf	cs
B2	40 - 80	Rb	5YR 4/6	SC	Msab	vh,f,ms,sp	ND	cs
B3	80 - 100	Rb	5YR 4/6	SC	Wsab	vh,f,np,ss	ND	ND
Ap	0 - 10	Db	10YR 3/3	SC	Msab	h,vf,ss,np	mf	cs
A1	10 - 47	Db	7.5YR 3/2	SC	Msab	h,vh,vf,ss,p	mf	gv
B1	47- 60	b,drb	7.5YR 4/2, 2.5 YR 3/4	SL	Msab	vh, vf,ss,p	ff	cs
B2	60 - 80	sb,g,yr	7.5YR 4/2, 2.5YR ¾	SL	Mab	vh, vf,vs,p	ND	cs
B3	80 - 90	G	10YR 5/1,	SL	Wsab	vh, f, np,ss	ND	cs

Texture: sl = sandy loam, sc = sandy clay, cs =clay sand, scl= sandy clay loam, s=sandy; [b]Structure: msab= medium sub angular blocky, wsab =weak sub angular blocky; [c]Consistence: h =hard, vh =very hard, ns = non-sticky, npl= non-plastic, h= hard, vh=very hard, vf= very firm, ss=slightly sticky, p=plastic, f=friable, nst =non-sticky, spl = slightly plastic, [d]Concretion: af = abundant fibrous, mf=many fibrous, ff-few fibrous, mcf= many coarse fibrous ccf=common coarse fibrous. Boundary: cs= clear smooth, wb=wavy boundary, ND = not determined.

Soil Classification

The soil of Lade values has a basement complex indicating the origin of the study soils. The soils of the upper slope were classified as Alfisols at order level and Ustalf at sub-order due to the clay illuviation at the B horizon and the humid/sub-humid environmental conditions under which the soils developed. At the great group the soil is grouped into Haplustalf based on the data showing average nutrient status. At subgroup level, the soil fitted into Rhodic Haplustalf due to Rhodic (Hue ≥ 2.5 YR) colour grade at the most of the horizons, the middle slope soils were classified as Inceptisol on basis of minimal horizon development within the profile. The lower slope soils were categorized an Entisol with no discernible diagnostic horizons. It had irregular distribution of organic carbon down the profile. At sub group level as Eutric as a result of base saturation, which is between 55 - 99%. Therefore, it was classified as Eutric-fluvaquent (Soil Survey Staff, 2010) and correlated as Fluvisols in the world reference base system. The soil moisture regime of the study area is ustic but underground water affected the soils of the valley bottom, the soil temperature regime was Isohyperthermic (USDA, 2010) and this correlates with the work done by Amusan and Ashaye, (1991) which states that soil temperature regime in south western -Nigeria can be classified as isohyperthermic. The soil texture were sandy loam and sandy clay down the profile, while the soil structure varied from medium sub angular blocky to weak sub angular blocky. The morphological descriptions of the soils are shown in table 5.

Table 5 Soil suitability using parametric approach

					Physical soil properties **(s)**			Nutrient availability **(f)**						Nutrient retention (n)			Suitability Index		Classes	
Soil profile	Soil series name	Topography slope **(t)**	Drainage (w)	Moisture avail. **(m)**	Texture	Gravel	soil Depth	N	P	K	Mn	Zn	Cu	ECEC	Base sat.	Organic matter	**a**	**p**	Actual	Potential
1	Iwo	100	100	100	95	100	20	100	60	100	100	60	95	60	100	100	4	11	NS_{sf}	NS_{s}
		100	100	100	95	90	20	100	60	100	100	20	95	60	100	100	1	10	NS_{sf}	NS_{s}
		100	100	100	95	100	50	100	60	100	100	20	85	60	100	95	1	3	NS_{snf}	NS_{sn}
		100	100	100	95	90	70	60	60	60	100	20	85	60	100	85	1	30	NS_{snf}	$S3_{sn}$
		100	100	100	95	100	100	20	20	20	100	20	85	60	100	85	1	48	NS_{nf}	$S3_{n}$
2	Balogun	100	100	100	95	100	20	100	60	100	100	20	85	60	100	100	1	11	NS_{snf}	NS_{sn}
		100	100	100	95	100	70	100	60	100	100	60	60	60	100	95	8	38	NS_{snf}	$S3_{sn}$
		100	100	100	95	100	70	100	20	100	100	20	60	60	100	95	1	38	NS_{snf}	$S3_{sn}$
		100	100	100	95	100	90	100	85	100	100	60	85	60	100	100	22	51	NS_{nf}	$S2_{n}$
		100	100	100	95	100	100	100	60	100	100	20	85	60	100	95	6	54	NS_{nf}	$S2_{n}$
3	Matako	85	100	90	95	95	20	100	60	100	100	60	85	60	100	100	3	8	NS_{snf}	NS_{sn}
		85	90	85	95	95	70	60	60	95	100	20	60	60	100	95	1	22	NS_{snf}	NS_{sn}
		85	90	90	95	95	90	100	20	100	100	20	85	60	100	100	1	34	NS_{nf}	$S3_{n}$
		85	90	85	95	95	90	100	20	100	100	20	85	60	100	95	1	30	NS_{nf}	$S3_{n}$
		85	90	90	95	100	90	100	60	100	100	60	85	60	100	95	10	33	NS_{nf}	$S3_{n}$

Parametric and geospatial techniques

Distribution of the actual and potential suitability of sub class for maize cultivation is shown in Table 5. The soils of the study area were found to range between moderately (S2), marginally (S3) and not suitable (NS). The limiting factors for S2 and S3 sub-classes are nutrient retention, fertility and physical soil properties, while for the potential suitability are nutrient retention and physical soil properties. It was observed that the suitability of the soil is hinders by the inappropriate allocation of land for any use and this therefore calls for the appropriate use of the land for the purpose it is best suited and this is also reported by Senjobi and Ogunkunle (2011). The suitability of the study soils can be improved with integration of organic and inorganic fertilizer which will help to resuscitate the soil nutrient for optimum yield of maize production in the study area. Furthermore, there must be appropriate agricultural management techniques (erosion control) that must be taken into consideration when these soils come under cultivation in order to have certainties in the yearly production of maize and hence offers farmers alternative land uses to lessen the risk of crop failure in the study area. The capability of GIS to analyze information across space and time has necessitated the increase in sustainable agriculture. The soil nutrients assessed in ArcGIS 10.1 were found to be moderately (S2), marginal (S3) and not suitable (NS). Maize suitability map of the study are shown in figure 2.

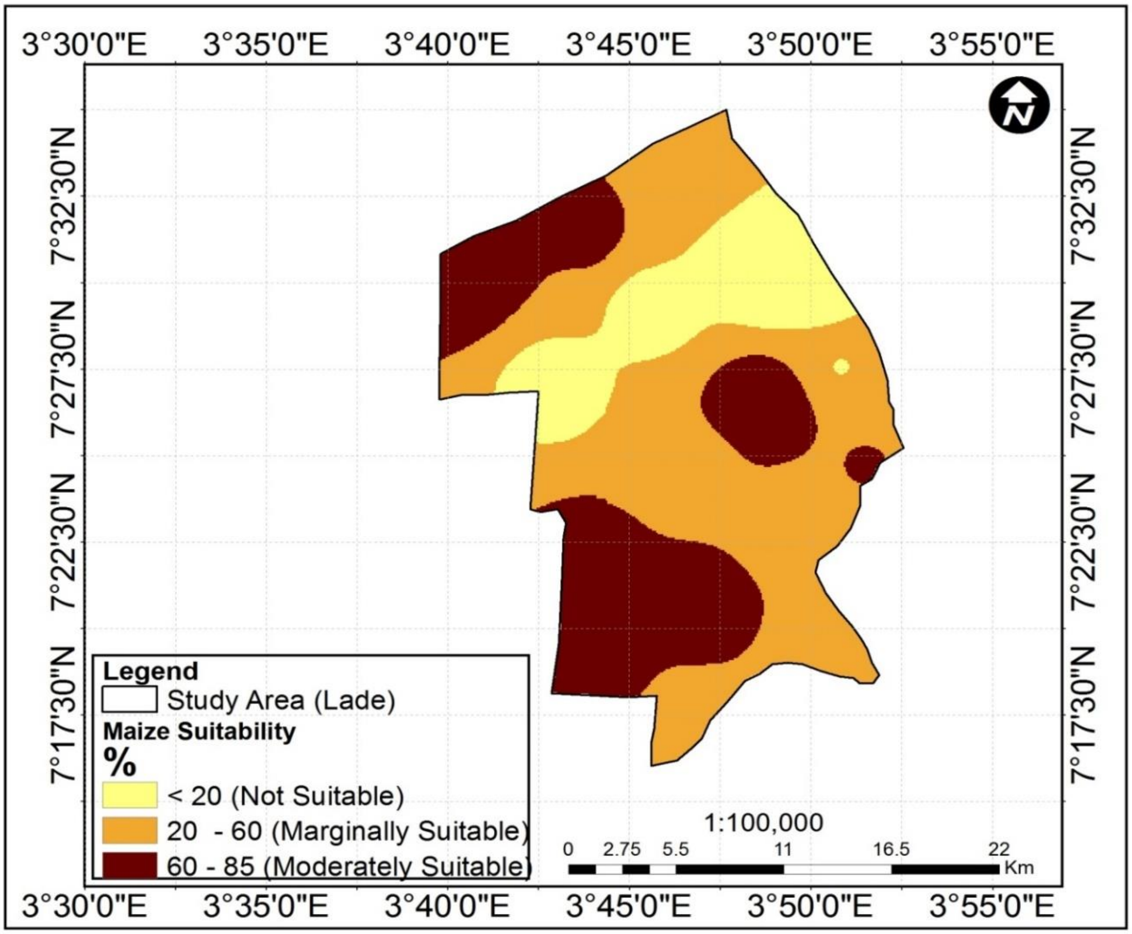

Figure 2 Maize Suitability

4. CONCLUSION

Appropriate land use decisions are vital in achieving optimum crop productivity. Hence, achieving optimum maize production requires an effective land information management and appropriate rate of fertilizers which will be made available for various soil users. It was found that conventional and digital soil mapping were moderately, marginally and not suitable, hence, this study shows that both techniques are accurate hence, digital soil mapping is faster, easily to update, and accessible which tends to be available for various soil and end users.

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Peer-review: External peer-review was done through double-blind method.

Data and materials availability: All data associated with this study are present in the paper.

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